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THE INTERRELATIONSHIP OF THE EGG RECORDS OF VARIOUS PERIODS DURING THE FIRST AND SECOND YEAR OF THE WHITE LEGHORN FOWL *

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I. Introduction

The primary purpose of this paper is to consider the interrelationship of the egg records of various periods during the second laying year of the White Leghorn fowl. It is, therefore, a continuation of earlier investigations in this general field, which have, of necessity, been limited to a consideration of the relationship between the periods of the first or pullet year (Harris and others, 1917-1921).

While our primary purpose has been the investigation of the correlations for the second laying year, these interrelationships can be fully understood only when considered in comparison with the like coefficients for the first year.

Fortunately the extensive data of the Vineland International Egg Laying and Breeding Contest permits the consideration of the complete first and second year record of 443 individual White Leghorn birds. Our problem is, therefore, to consider all of the more important correlations between the egg records of the periods of the second year, and to compare them with the homologous coefficients for the periods of the first year. Thus, while the present investigation marks an entirely new advance in the investigation of the inter-periodic correlation in the egg laying activity of the domestic fowl (in that it deals with the productions of the second laying year, which have hitherto received but

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little attention), it also furnishes an extensive supplementary series of such correlations for the first year which are available for comparison with those already deduced for the White Leghorns (Harris and others, *loc. cit.*) and for the Rhode Island Reds (Harris and Goodale, 1922).

II. Materials

The data for 443 Single Comb White Leghorn birds upon which the constants here discussed are based are derived from the records of the First International Egg Laying and Breeding Contest at Vineland, New Jersey. Details concerning this contest have been sufficiently described by one of us (Lewis and others, 1916-1920). Further statistical data are given in two earlier publications on the White Leghorn breed (Harris and Lewis, 1921, 1922).

TABLE I

Comparison of correlation between monthly egg production and annual egg production, and monthly egg production and the record of the remaining eleven months of the first year.

Month	Correlation with total production	r/E_r	Correlation with other eleven months production	r/E_r	Difference	Percentage reduction
November	.5360 ±.0228	23.51	.3840 ±.0273	14.07	—.1520	28.4
December	.6509 ±.0185	35.18	.5155 ±.0235	21.94	—.1354	20.8
January	.6309 ±.0193	32.69	.4996 ±.0241	20.73	—.1313	20.8
February	.5138 ±.0236	21.77	.3941 ±.0271	14.54	—.1197	23.3
March	.4918 ±.0243	20.24	.4125 .0266	15.51	—.0793	16.1
April	.4680 ±.0250	18.72	.3987 ±.0270	14.77	—.0693	14.8
May	.4790 ±.0247	19.39	.3961 ±.0270	14.67	—.0829	17.3
June	.4386 ±.0259	16.93	.3340 ±.0285	11.72	—.1046	23.8
July	.5005 ±.0240	20.85	.3761 ±.0275	13.68	—.1244	24.9
August	.6051 ±.0203	29.81	.4720 ±.0249	18.96	—.1331	22.0
September	.6424 ±.0188	34.17	.5092 ±.0237	21.49	—.1332	20.7
October	.5407 ±.0227	23.82	.4048 ± 0268	15.10	—.1359	25.1

TABLE II

Comparison of correlation between monthly egg production and annual egg production, and monthly egg production and the record of the remaining eleven months of the second year.

Month	Correlation with total production		r/E_r	Correlation with other eleven months production		r/E_r	Difference	Percentage reduction
November	.3467	.0282	12.29	.2113	.0306	6.91	—.1354	39.1
December	.3272	.0285	11.44	.2219	.0305	7.28	—.1053	32.2
January	.4188	.0264	15.86	.3008	.0291	10.34	—.1180	28.2
February	.4643	.0251	18.50	.3388	.0284	11.93	—.1255	27.0
March	.5549	.0222	25.00	.4682	.0250	18.73	—.0867	15.6
April	.4795	.0247	19.41	.3805	.0274	13.89	—.0990	20.6
May	.5324	.0230	23.15	.4196	.0264	15.89	—.1128	21.2
June	.5947	.0207	28.73	.4801	.0247	19.44	—.1146	19.3
July	.6647	.0179	37.13	.5362	.0228	23.52	—.1285	19.3
August	.7206	.0154	46.79	.5843	.0211	27.69	—.1363	18.9
September	.7257	.0152	47.74	.6054	.0203	29.82	—.1203	16.6
October	.5204	.0234	22.24	.4108	.0266	15.41	—.1096	21.1

III. Presentation and Analysis of Data

1. *The correlation between the records of the individual months and the annual egg records.*

The coefficients showing the relationship between the egg production of the individual months and of the year as a whole appear in table 1 for the first and in table 2 for the second laying year. The coefficients vary considerably among themselves in each year. They are represented graphically by the series of solid dots bordering the shaded areas in the two figures of diagram 1. These show that for the first year the correlations for November and October are somewhat lower than those for December and January, and August and September, but higher than those for the period from February to July. In the second year the correlations increase with fair regularity from November to September, but the October correlation is materially lower than the September constant. It does not seem desirable to dis-

cuss the relative magnitude of the correlations for the individual months in greater detail since constants for other breeds are being made ready for comparison, and all may be considered at the same time.

We may in passing note from table 3 that the coefficients for November to February inclusive, are larger in the first year than in the second year, while those for March to September are larger in the second year. A number of these differences may be considered statistically significant in comparison with their

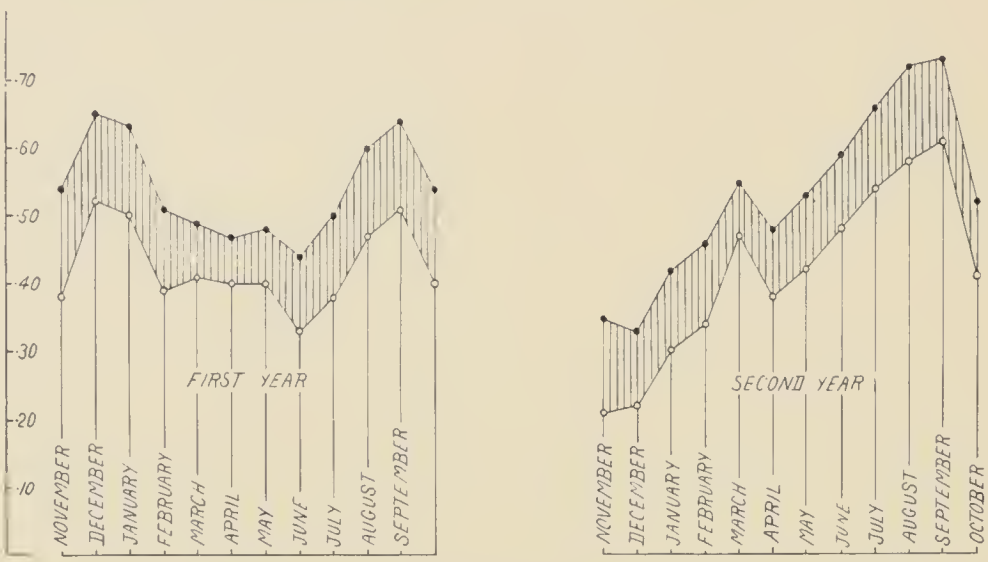

Diagram 1. Magnitudes of correlations between the egg record of the individual months and the egg record of the whole year (solid dots) and of the correlations between the egg record of the individual months and the total egg production of the remaining eleven months of the year (circles). The shaded area indicates the magnitude of the difference between these values.

probable errors. The difference for October is a slight exception to the other autumn months.

The average values of the 12 coefficients are

For first year, ---------- .5415

For second year ---------- .5292

These show that the coefficients are, roughly speaking, equally large in the two years. Prediction of annual production from the record of any month should, therefore, be possible with a considerable degree of accuracy, providing that regression be linear.

Graphic tests for the linearity of the regression equation relat-

ing first year annual production to the productions of the individual months have already been provided for the White Leghorn breed as studied at Storrs (Harris, Blakeslee and Kirkpatrick, 1918, p. 33-39, diag. 2-5) and for the Rhode Island Red breed as studied at Amherst (Harris and Goodale, 1922, diag. 1-3). The form of the regression equation showing the relationship between second year total production and first year monthly production has also been investigated for this series of White Leghorn birds (Harris and Lewis, 1922, diag. 5-6). It seems unnecessary, therefore, to consider the equations showing the relationship between the annual record of the first year and the monthly records of this year in the present series. It does, however, seem worth while to determine whether a series of straight lines will represent reasonably well the relationship between the records of the individual months of the second year and the annual record of the second year.

The straight line regression equations for both the first and the second year are shown in table 4.

The straight lines and the empirical means for the second year production are shown on the 12 figures of diagrams 2 and 3.

While regression cannot be definitely asserted to be strictly linear in every instance (and will indeed probably be shown to be sensibly non-linear for certain months when sufficient biological data are available to make a crucial mathematical test possible), it is clear that as a first approximation the straight lines represent the means reasonably well.

The essential linearity of the regression of second year total production on the second year monthly productions shows that prediction equations of the type developed for first year production in the White Leghorn (Harris, Kirkpatrick, Blakeslee, Warner and Card, 1921) may, if it proves desirable, be developed for the prediction of total second year production from the records of the individual months. At present, adequate data for the calculation and testing of standard equations of this kind are not available. The increasing interest of those who have charge of the various contests in second year production will ultimately result in the collection of such data.

2. *The correlation between the records of the individual months and the records of the remaining eleven months of the year.*

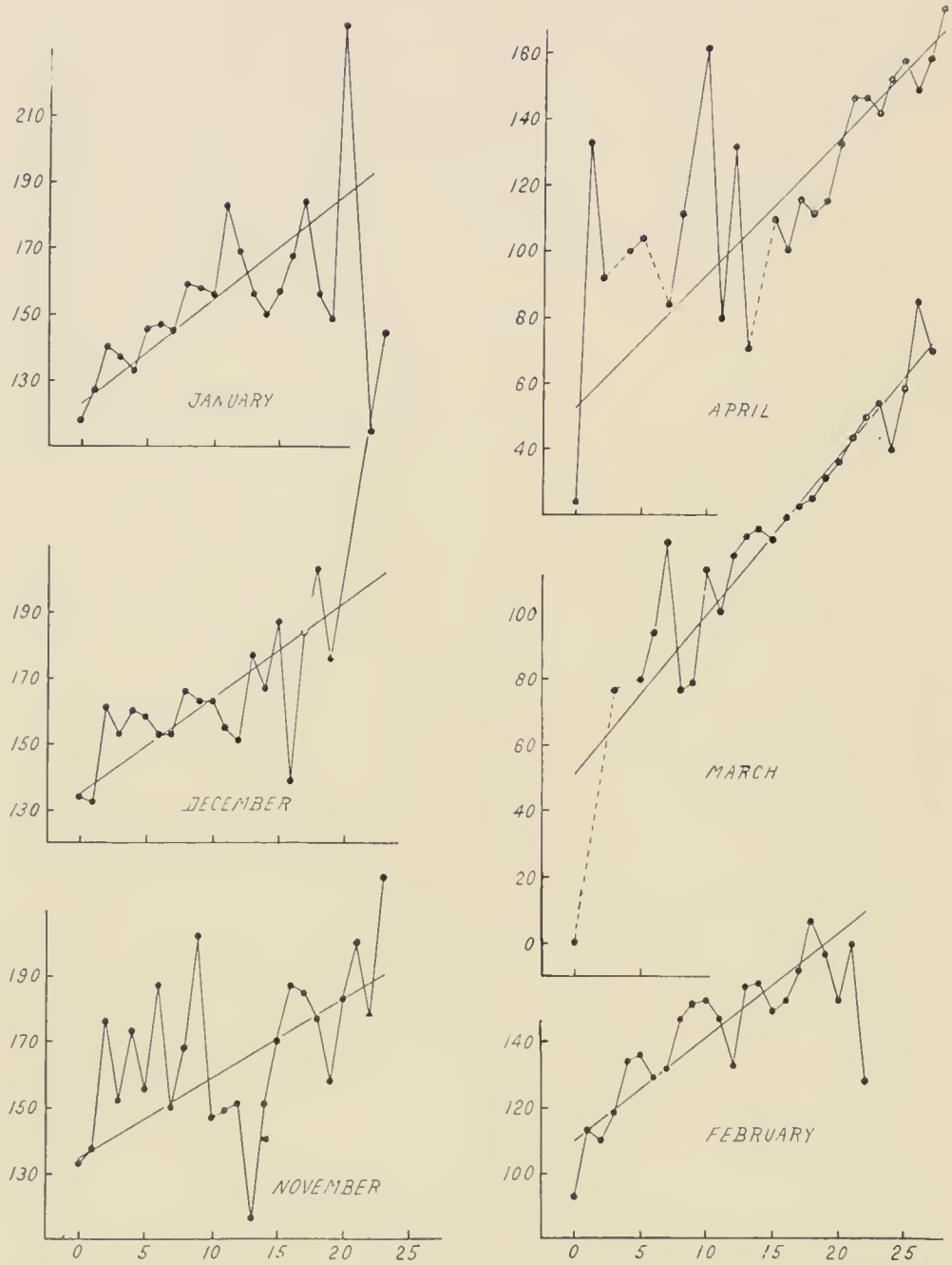

Diagram 2. Regression of annual production on monthly production in the second year.

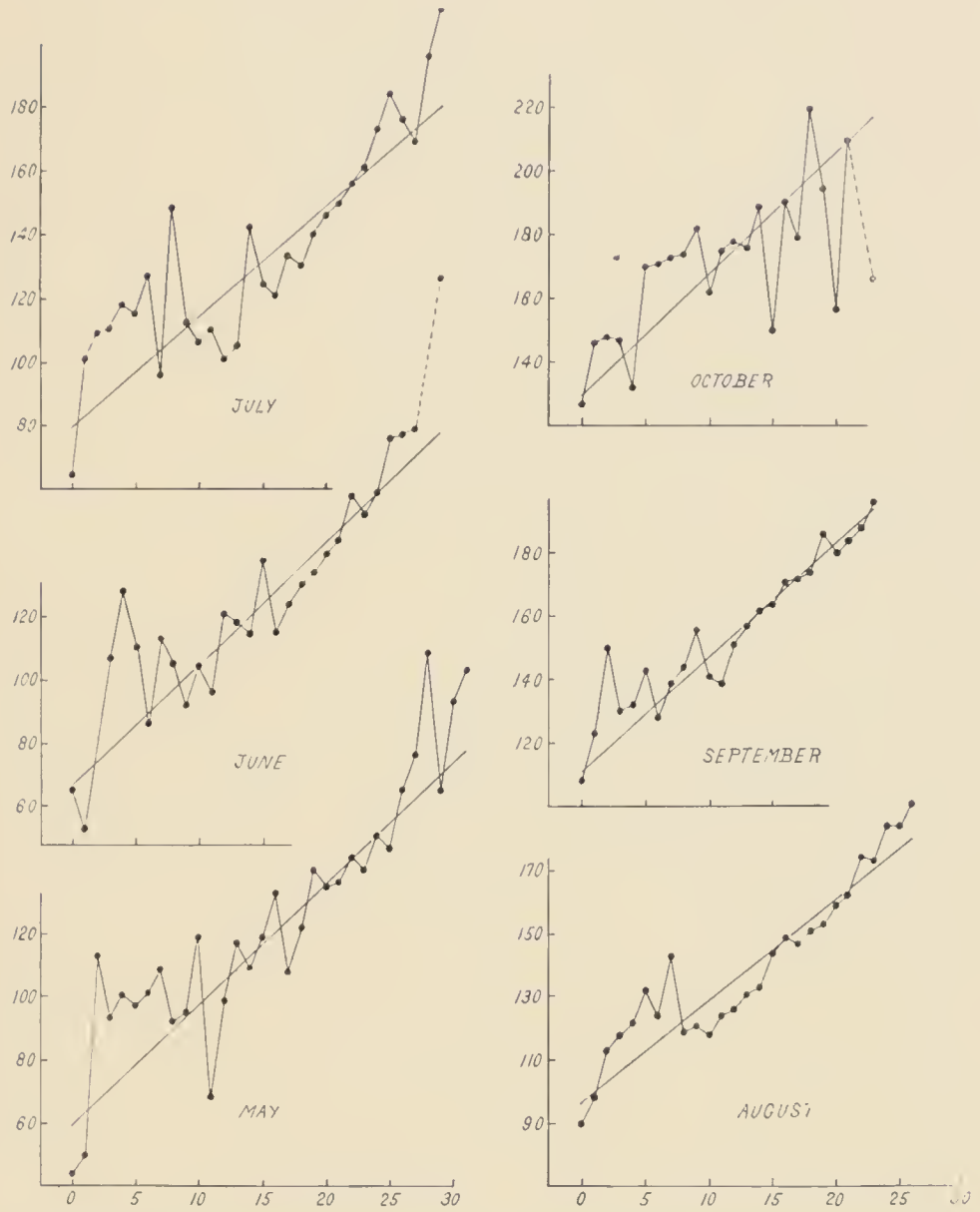

Diagram 3. Regression of annual production on monthly production in the second year.

While the correlations between the individual months production and the annual total is the constant of greatest economic importance, since it furnishes the foundation of the equations for the prediction of annual production from the record of minor periods, it is somewhat misleading physiologically. In correlating between the record of an individual month and the record of the year as a whole we are determining the relationship between the record of a minor period and of a major period in which the record of the individual month is one of the components. We have, therefore, determined as in an earlier paper (Harris, Blakeslee and Kirkpatrick, 1918, p. 44-45, diag. 1) the correlation between the record of the individual months and the total record of the other 11 months of the year.

The coefficients showing the relationship between the production of the individual months and the eleven other months of the year appear in the second correlation column of table 1 for the first year and table 2 for the second year. These coefficients are represented graphically by the circles bordering the shaded areas in the two figures of diagram 1. The differences between the two coefficients and the percentage reduction in the correlation resulting from the elimination of the individual month used as first variable from the annual total is shown in the two final columns of tables 1 and 2. The difference is also represented graphically by the breadth of the shaded area in diagram 1. The actual magnitude of the reduction may be seen from the differences or from the relation of the shaded to the unshaded area in the figures of diagram 1. It may be noted that the correlations for the eleven month periods follow very closely indeed those for the twelve month periods.

We now have to compare the correlations between the individual months and the annual totals and the individual months and the eleven month totals as deduced from the first year and the second year performance of the birds. The differences deduced from tables 1 and 2 appear in table 3.

These differences show that the correlations between the individual months production and the total production of the remaining eleven months are higher for the first year in November, December, January and February, whereas they are generally lower for the first year in March to October. A number of these differences may be considered clearly significant in comparison

TABLE III

Comparison of correlations for first and second year. For the constants upon which the differences are based see table I for first year production and table II for second year production.

Month	Differences in Correlation between monthly production and total production		$\frac{diff}{E_{diff}}$	Difference in Correlation between monthly production and the remaining mo. prod'tion		$\frac{diff}{E_{diff}}$
November	−.1893	.0362	5.23	−.1727	.0410	4 21
December	−.3237	.0340	9.52	−.2936	.0385	7.63
January	−.2121	.0327	6.49	−.1988	.0377	5.27
February	−.0495	.0344	1.44	−.0553	.0392	1.41
March	+.0631	.0329	1.92	+.0557	.0365	1.53
April	+.0115	.0351	0.33	−.0182	.0384	0.47
May	+.0534	.0337	1.58	+.0235	.0377	0.62
June	+.1561	.0331	4.72	+.1461	.0377	3.88
July	+.1642	.0299	5.49	+.1601	.0357	4.48
August	+.1155	.0254	4.55	+.1123	.0326	3.44
September	+.0833	.0241	3.46	+.0962	.0312	3.08
October	−.0203	.0326	0.62	+.0060	.0377	0.16

TABLE IV

Regression equations for the prediction of annual egg production from monthly egg records.

Month	Regression equations	
	First year	Second year
November	$E = 143.833 + 2.899\ e_1$	$E = 134.384 + 2.409\ e_1$
December	$E = 139.474 + 3.351\ e_2$	$E = 134.525 + 2.919\ e_2$
January	$E = 141.061 + 3.438\ e_3$	$E = 123.499 + 3.164\ e_3$
February	$E = 132.072 + 3.522\ e_4$	$E = 110.183 + 3.193\ e_4$
March	$E = 71.290 + 5.042\ e_5$	$E = 50.890 + 4.863\ e_5$
April	$E = 52.494 + 5.582\ e_6$	$E = 53.277 + 4.050\ e_6$
May	$E = 68.742 + 4.772\ e_7$	$E = 59.899 + 3.774\ e_7$
June	$E = 95.902 + 3.653\ e_8$	$E = 66.608 + 3.844\ e_8$
July	$E = 107.135 + 3.358\ e_9$	$E = 78.701 + 3.497\ e_9$
August	$E = 121.251 + 3.365\ e_{10}$	$E = 96.003 + 3\ 256\ e_{10}$
September	$E = 152.126 + 3.398\ e_{11}$	$E = 111.551 + 3.586\ e_{11}$
October	$E = 160.823 + 3.214\ e_{12}$	$E = 129.501 + 3.837\ e_{12}$

with their probable errors. Thus these results are in general agreement with those for annual production given in table 3 and discussed above.

Before an interpretation of these results is undertaken it will be desirable to determine whether this is a general law or whether it may possibly be due to some peculiarity of the flocks or of the meteorological or other conditions of the two years under consideration here. This task must await the assembling of further biological data.

IV. Summary and Conclusions

The primary purpose of the present paper is the presentation of the results of a biometric investigation of the relationships between the egg records of various periods in the second laying year of the White Leghorn fowl. For purposes of comparison the homologous correlations for the first year are also determined.

The results show that the correlations between the productions of the individual months and the annual total in the second year are, roughly speaking, comparable in magnitude with those which have been demonstrated for the first year production in previous investigations on the White Leghorn, the Rhode Island Red and the White Wyandotte breeds. This is also true of the correlation between monthly egg record and the egg record of the other eleven months of the year.

The regression of total annual production on monthly production in the second year is, roughly speaking, linear. Thus the prediction of annual production from monthly records should be possible with the same order of accuracy as in the first year.

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